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Planting Guidelines for Seagrasses

by

Ronald C. Phillips

COASTAL ENGINEERING TECHNICAL AID NO. 80-2

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An intensive review was made of the historical and present work on transplanting seagrasses, including eelgrass, turtle grass, shoalgrass, manatee grass, and ditch grass. The best seasons, recommended methods of transplanting, and propagules to use for each species are listed for the coasts of the United States. Some of the more important environmental parameters which directly influence successful transplanting are reviewed.

PREFACE

This report is published to assist coastal engineers in the planning, design, and implementation of transplanting seagrasses to restore areas damaged by coastal engineering projects and to stabilize substrates adjacent to navigation channels.

The report was prepared by Ronald C. Phillips, School of Natural and Mathematical Sciences, Seattle Pacific University, Seattle, Washington, under CERC Contract No. DACW72-79-C-0030. Some of the material in the report is based on research supported in part by the National Science Foundation, International Decade of Ocean Exploration.

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Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

Ted E. Bishop
TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

A

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

PLANTING GUIDELINES FOR SEAGRASSES

by

Ronald C. Phillips

I. INTRODUCTION

Seagrasses play an important role in the biological and physical functions of the coastal marine environment. However, increased coastal engineering activities in the environment have created impacts which adversely affect this productive coastal resource. Seagrasses, once disturbed, do not reestablish as readily as terrestrial plants.

Because seagrass beds may be damaged by coastal engineering activities, methods must be made available to mitigate these project impacts and further the use of seagrasses to stabilize substrate adjacent to navigation channels. This report provides a state-of-the-art field guide on the planting of seagrasses.

II. SELECTING PLANTS AND PLANTING METHODS

The appropriate species and planting method may be determined in the following manner.

STEP ONE: Select the description from each of the following categories which best describes the site to be planted.

GEOGRAPHICAL AREA

Atlantic coast (north of Beaufort, North Carolina)
Gulf coast and from Beaufort, North Carolina, to southern Florida
Pacific coast

TIDAL ELEVATION

Mean low water (MLW) to mean tide level (MTL) or MLW to -6 feet (-1.8 meters) on the Atlantic and gulf coasts

Mean lower low water (MLLW) to lowest high low water (LHLW) or MLLW to -6 feet on the Pacific coast

TIDAL CURRENTS

0 to 3.5 knots (6.5 kilometers per hour)
$>$3.5 knots

SALINITY

0 to 20 parts per thousand
21 to 40 parts per thousand
$>$40 parts per thousand

SOIL PROPERTIES

Mostly cohesive (silts and clays)
Combination of cohesive and granular
Mostly granular (sand)

Tidal elevations in most cases should be determined by elevational surveys.

Tidal currents are only limiting in some areas of the Atlantic coast where tidal flow is restricted, e.g., the inlets along the Rhode Island coast, and along the Pacific coast where the tidal range between two successive tides commonly exceeds 8 feet (2.4 meters). Tidal current velocities can be found in tide tables published by the National Ocean Survey (NOS).

Salinity regimes for local waters are available from State departments of natural resources, academic institutions, the National Oceanic and Atmospheric Administration (NOAA), and local U.S. Fish and Wildlife Service Refuges, bait houses, or boat marinas. If unavailable, salinity should be measured.

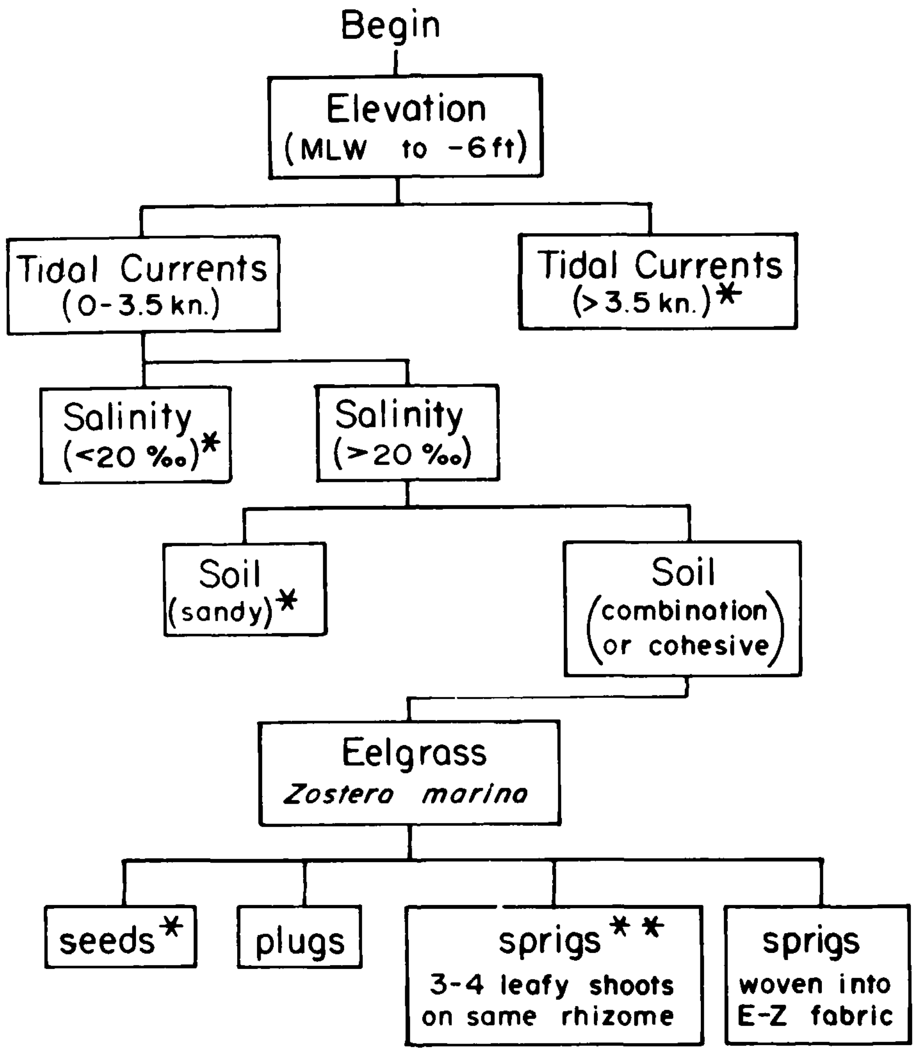
Wave energy can limit or prevent seagrass growth. Where wave energy is high, sediments tend to be coarse and seagrasses are sparse or absent. Where wave energy is low, sediments tend to be cohesive and seagrasses are abundant and dense. In the following planting keys (Figs. 1,2, and 3) substrate types indicate protection from adverse wave action.

STEP TWO: Turn to the planting decision key (Fig. 1 if site is located on the Atlantic coast north of Beaufort, North Carolina; Fig. 2 if site is south of Beaufort, North Carolina, to Florida and along the gulf coast; Fig. 3 if on the Pacific coast). Using the appropriate planting decision key and the site description compiled in Step One, begin at the top of the key and move downward following the appropriate path. The path will terminate in a block which either designates suitable plant species and planting methods or indicates the site is not appropriate for planting.

III. OBTAINING PLANT MATERIALS

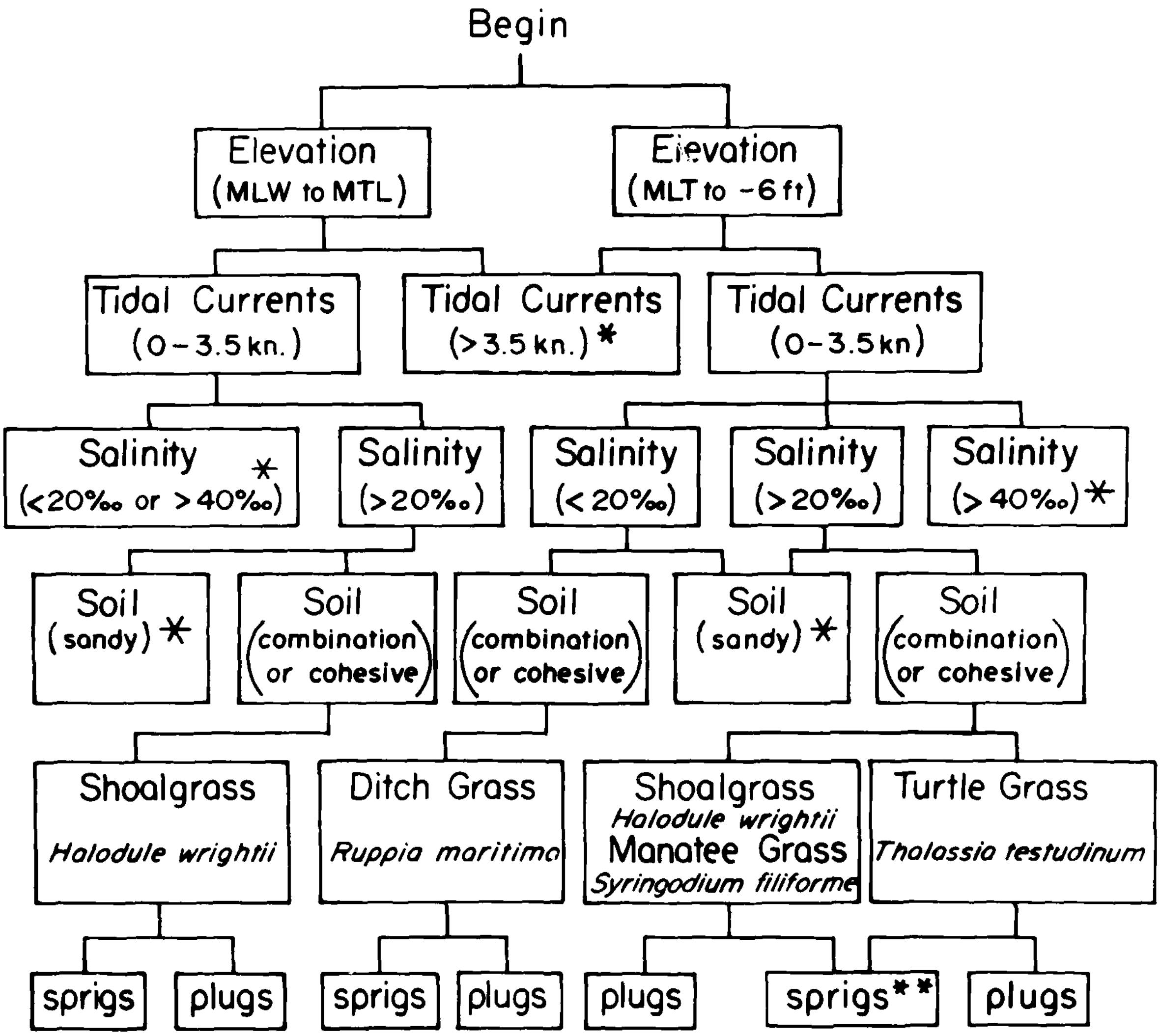
No nursery techniques have been developed for growing and distributing seagrasses for revegetation projects. Seagrasses are obtained from nearby native stands of the desired species on the date of intended use. Material can be transported in containers covered with wet canvas or burlap. Plants must be kept moist, cool, and shaded until planting.

Vegetative and reproductive stages of the various species of seagrasses used in transplanting are illustrated in Figure 4 (eelgrass, *Zostera marina*), Figure 5 (shoalgrass, *Halodule wrightii*), Figure 6 (turtle grass, *Thalassia testudinum*), Figure 7 (manatee grass, *Syringodium filiforme*), and Figure 8 (ditch grass, *Ruppia maritima*).



* Do not plant
** Least cost planting method

Figure 1. Planting decision key, Atlantic coast north of Beaufort, North Carolina.



* Do not plant
** Do not plant manatee or turtle grass by sprigs

Figure 2. Planting decision key, Atlantic coast south of Beaufort, North Carolina, to Florida and along the Gulf Coast.

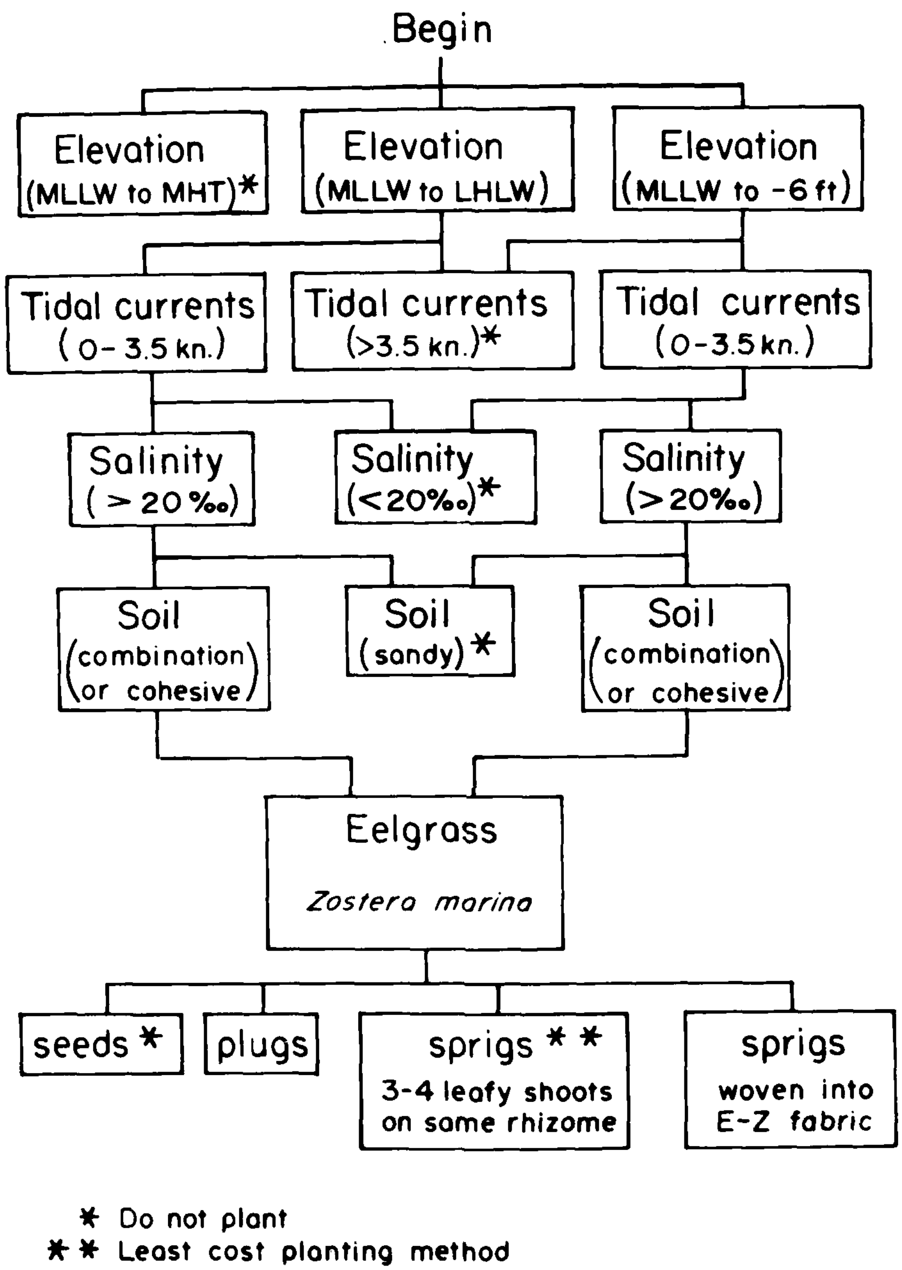


Figure 3. Planting decision key, Pacific coast.

Figure 4. Eelgrass -- (a) vegetative plant, (b) part of spadix with mature seeds.

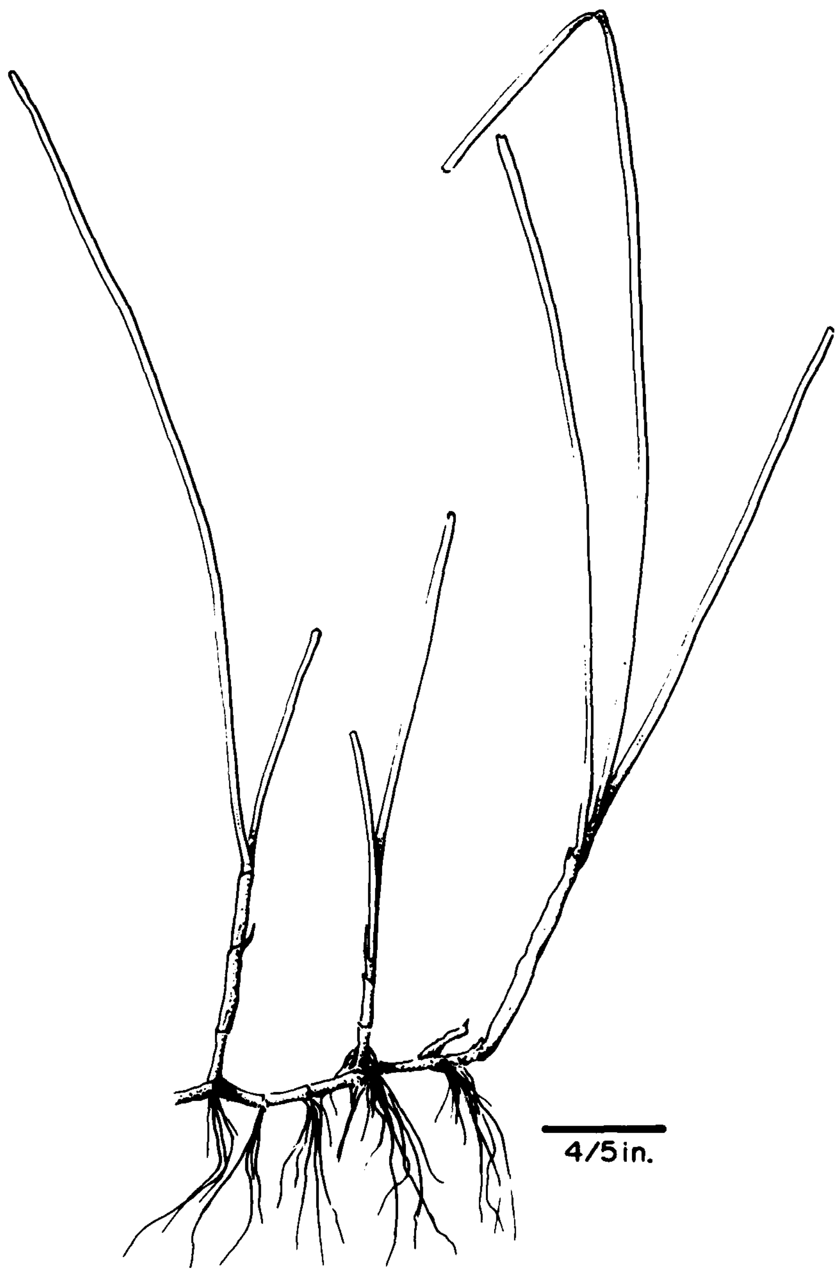


Figure 5. Vegetative shoalgrass.

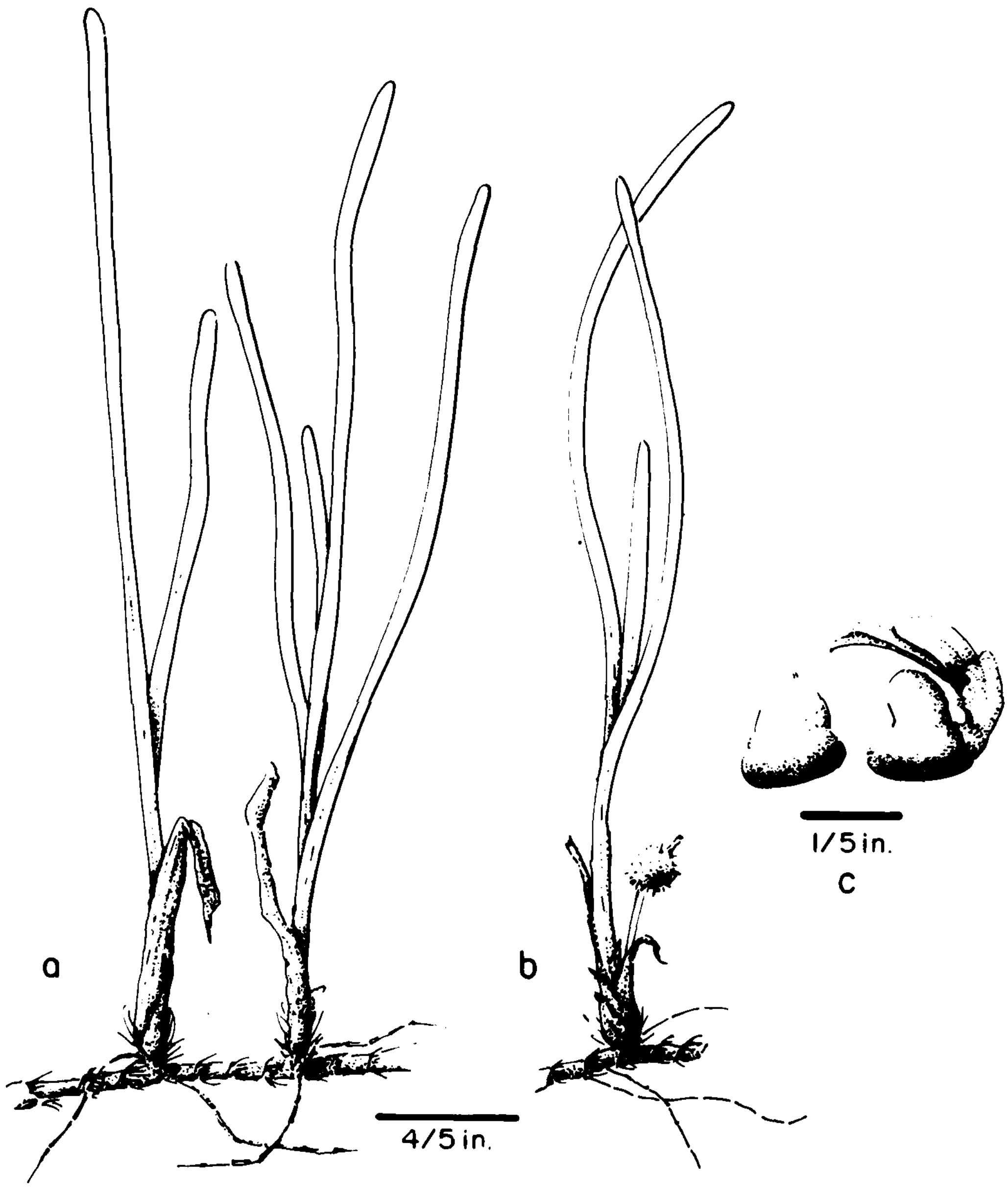


Figure 6. Turtle grass -- (a) vegetative plants, (b) reproductive plant with mature fruit, (c) seed and seedling.

Figure 7. Vegetative manatee grass.

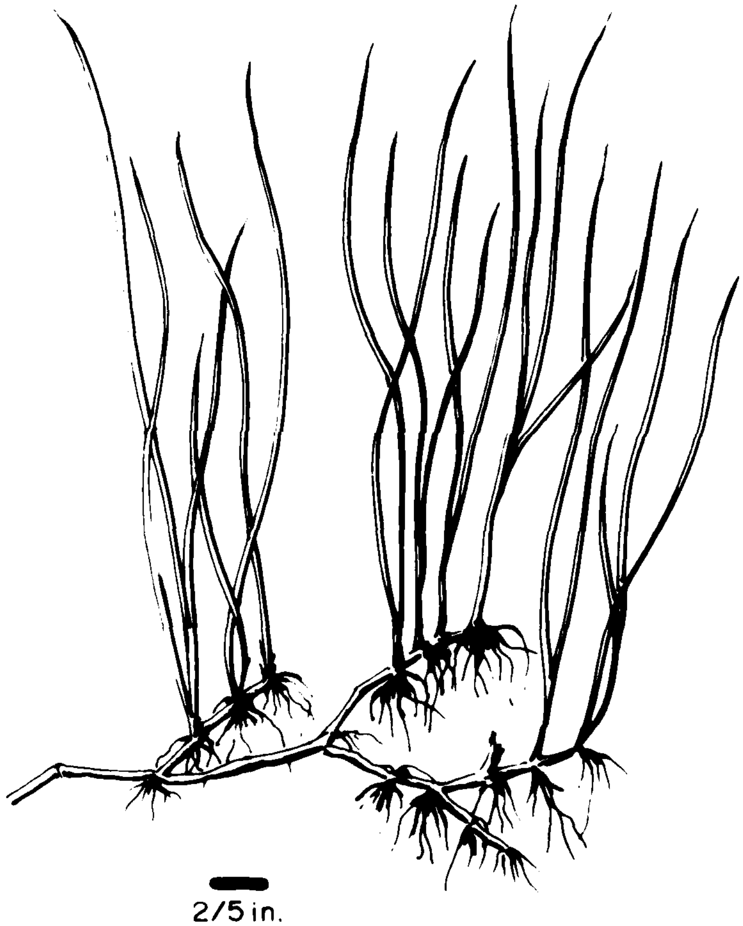


Figure 8. Vegetative ditch grass.

IV. PLANTING METHODS

1. Seeding.

Seeding turtle grass has been successful. Seeds are ready for harvest as early as mid-July and can be planted as late as November. If holding methods are used, seedlings could be planted during September, October, or November. Thorhaug (1974) discussed various methods for holding seeds.

Seeds may be collected from mature fruits (0.5 to 1.5 inches or 1.3 to 3.8 centimeters wide) or as germinated seedlings lying on the sediment surface. To harvest, clip the fruit from the stalk and break open the spongy ovary wall to expose the four to five seeds. Seeds and seedlings may be planted immediately or stored in the field or in the laboratory if irrigated with flowing seawater (Thorhaug, 1974). Because seeding techniques are poorly understood, seeding is not recommended for general use by those inexperienced in planting seagrasses.

Seeding has not been successful with any other seagrass species. In general, seeds of other species are extremely small and easily washed out, and germination rates are low.

2. Planting Sprigs Unanchored.

For eelgrass and shoalgrass, sprigs of leafy shoots have been successful. These sprigs consist of a small bunch of 3 to 4 shoots (eelgrass) or 15 to 20 shoots (shoalgrass) on the same rhizome. The sprigs should be planted by digging a small hole in the substrate (about 3 inches or 8 centimeters deep), placing the sprigs in the hole, and covering over with the same substrate. This technique is only successful where wave or current energies are low.

3. Planting Plugs.

Plugs are cores of plants with substrate intact. Diameter of plugs can be as small as 4 inches (10 centimeters), for shoalgrass, to a recommended 6 to 8 inches (15 to 20 centimeters), for eelgrass, turtle grass, and manatee grass.

A cylindrical coring device (e.g., a PVC sewer pipe with a wooden handle) is pushed into a donor grass bed to obtain the plug (Fig. 9). The grass plug is then transplanted in a hole, 6 to 8 inches deep, dug by the same coring device.

Phillips, Vincent, and Huffman (1978) recommended that plugs of shoalgrass for transplanting be taken 1.5 feet (46 centimeters) or more apart in natural stands. At Port St. Joe, Florida, several large open spaces resembling blowouts were observed in the shoalgrass donor site where plugs had been taken at 6-inch intervals. Where the plugs had been taken at 12-inch (30 centimeters) intervals no blowouts had occurred, and after 1 year, the bottom had nearly recovered from regrowth of surrounding shoalgrass.

Figure 9. PVC coring device being used to remove plugs of shoalgrass.

4. Planting Sprigs Anchored.

In areas where currents exceed 1.5 knots (about 3 kilometers per hour) or there is slight wave energy exposure from wind, storm, or even boat wakes, it is advisable to use anchoring devices with seagrass sprigs. In Mississippi Sound, Eleuterius (1974) found that construction rods and iron mesh painted with vinyl paint, when used as anchoring devices, did not affect turtle grass and shoalgrass sprigs. He concluded that bare metal would not kill the plants. Phillips (1976) found that turtle grass and shoalgrass in Texas and eelgrass in Alaska were killed when metal anchors were used. In Puget Sound, Washington, eelgrass appeared to be unaffected by iron or metal anchors.

Because of the increasing costs of construction rods and wire mesh, and the susceptibility of certain seagrasses to iron, it is recommended that E-Z fabric be used. E-Z fabric is a combination of synthetic-fiber netting (polypropylene yarn) interwoven with biodegradable paper strips (Gulf States Paper Corp., Tuscaloosa, Alabama). The material is inexpensive, \$85 for a roll 300 feet (91.4 meters) long and 54 inches (137.2 centimeters) wide, 1979 prices. Fonseca, et al. (in preparation,

1980) cut the netting into 8- by 8-inch (20 by 20 centimeters) squares and wove 15 eelgrass shoots through each mesh square, leaving the rhizomes on the underside of the mesh. The square was then pinned to the substrate surface. In 3 months the bottom coverage of the plants expanded 400 percent, and the plants became anchored. Many plants can be quickly planted by this technique. Labor is required for weaving seagrasses through the mesh, but this is done in the field. The only work to be done in the water is collecting the plants, washing them free of the substrate, and then pinning the squares to the substrate. The only problem encountered using this method was in Puget Sound where dungeness crabs rooted out the plants.

V. PLANTING TIME

Generally, the best time of the year for transplanting seagrasses is in the spring. However, transplanting may be done anytime during the year on the Gulf of Mexico, the Atlantic coast south of Beaufort, North Carolina, and the Pacific coast from Washington State to southern California, i.e., areas free from sea ice in winter, although specific times (see Table 1) have been recommended by prior studies (Churchill, et al., 1978; Phillips, 1976; Phillips, Vincent, and Huffman, 1978; Thorhaug, 1974, 1976). North of Beaufort on the Atlantic coast and in Alaska on the Pacific coast, where there is sea ice in winter, transplanting should be done when the ice melts and vegetative plants begin growing. Table 1 lists the recommended transplanting times by species and location.

1. Eelgrass.

a. Atlantic Coast North of North Carolina and Alaska, Pacific Coast.

Transplanting should be done as soon as vegetative plants appear following the melting of sea ice. This could be March in mild winters or mid-May if ice persists until March. Transplanting should be completed by mid-June to ensure establishment and growth of the eelgrass before the next winter.

b. Atlantic Coast, South of Beaufort, North Carolina, and Washington State to California, Pacific Coast.

The best time to transplant in these areas varies. At Beaufort most of the eelgrass produces seeds from late January to April. Late September to early December is the best time for transplanting at Beaufort. This period escapes the heat stress of the summer when water temperatures are up to 86° Fahrenheit (30° Celsius).

From Washington State to southern California, January to May is the best time to transplant. This is the period of active vegetative growth. However, transplanting can be done throughout the year.

2. Turtle Grass, Shoalgrass, Manatee Grass, and Ditch Grass.

Prior studies show that winter plantings (December to April) give the best results with respect to survival and growth throughout the range of these species.

Table 1. Recommended transplanting times.

Species	Location	Recommended time
Eelgrass	Alaska and Atlantic coast north of North Carolina	Mar. (mild winters) or May (severe winters) to late July
	Beaufort, North Carolina, south of Atlantic coast	Late Sept. to early Dec.
	Washington State to southern California, Pacific coast	Jan. to May (but can be done throughout the year)
Shoalgrass, Ditch Grass	Gulf coast, Atlantic coast south of Cape Canaveral, Florida	Anytime during year
Turtle Grass, Manatee Grass	Gulf coast, Atlantic coast south of Cape Canaveral, Florida	Plugs: Dec. to Apr. Seedlings of turtle grass: Aug. to Nov. as they are produced in the field.

Shoalgrass can probably be transplanted successfully any time of the year. Turtle grass appears to be less tolerant of summer heat stress, so transplanting should be limited to December, January, and February. There is not enough information on manatee grass and ditch grass to indicate a best time for transplanting; however, manatee grass appears to be similar to turtle grass in its requirements and tolerances.

VI. SEED APPLICATION RATE AND PLANT SPACING

1. Seeding.

Seeding is not recommended for eelgrass (Phillips, 1972; Churchill, Cok, and Riner, 1978). Flowering stalk production is variable from year to year. Only 6 to 14 percent of the plant population produces stalks. Seed germination at ambient water temperatures is low (about 2 percent in Puget Sound, Washington, and never more than 30 percent in Great South Bay, New York).

Thorhaug (1974) and Thorhaug and Austin (1976) reported on a large turtle grass seeding project in Biscayne Bay, Florida. They obtained

Table 2. Estimated transplantation costs.

Species	Source	Method Used	Costs (per acre)
Eelgrass	Fonseca et al. (in preparation, 1980)	Fifteen vegetative shoots woven through E-Z fabric mesh	$14,970 (to get complete cover in 250 days; planted in water less than 3 ft deep)
		Plugs[1]	$76,545 (based on cost per shoot)
	Churchill, Cok, and Riner (1978)	Sprigs (3 to 4 vegetative shoots on same rhizome planted by hand)	$12,775 (1-ft spacing; planted less than 4 ft deep; 1,655 man-hr)
			$3,370 (2-ft spacing; planted less than 4 ft deep; 414 man-hr)[2]
			$1,645 (3-ft spacing; planted less than 4 ft deep; 189 man-hr)[3]
	Robilliard and Porter (1976)	Plugs[1]	$25 per ft^2 of eelgrass (sufficient for two normal plugs; 19,400 plugs per acre needed for 18-in spacing = $242,500 per acre; 4,840 plugs per acre needed for 36-in spacing = $60,500 per acre; 1 man-hr needed to obtain, move, and plant 1.08 ft^2 of eelgrass)
Turtle grass	Thorhaug and Austin (1976)	Seedlings	$33,385 for a cover of 278 blades per ft^2 in 2.5 years (does not include transportation costs, depreciation costs, or administrative overhead; based on $.064 per 93 blades per ft^2)
			$111,286 for a cover of 93 blades per ft^2 in 0.8 year (based on $.064 per 93 blades per ft^2)
			$222,572 to get cover of 185 blades per ft^2 in 0.8 year (based on $.064 per 93 blades per ft^2)

[1]Cost for Gulf of Mexico species should be same.

[2]Recommended spacing owing to costs and growth rate.

[3]Not recommended because of the shorter growing season.

80 percent success in germination and establishment of seedlings. Seed application rates varied from 19 to 0.09 per square foot (200 to 1 per square meter). Success rates did not differ for the varying application rates.

2. Sprigs, Plugs, and Sprigs Woven Into E-Z Fabric.

There has not been extensive research into determining optimal spacing for seagrass transplants; however, several successful spacings have been reported (see Literature Cited).

Churchill, Cok, and Riner (1978) planted sprigs and plugs of eelgrass spaced at 13-inch (33 centimeters) intervals on dredged materials in Great South Bay, New York. Fonseca, et al. (in preparation, 1980) planted sprigs of eelgrass woven into 8- by 8-inch squares of E-Z fabric, spaced at 3-foot (0.9 meter) intervals. When planted in October the eelgrass extended bottom coverage 400 percent in 3 months.

Phillips, Vincent, and Huffman (1978) planted shoalgrass plugs at 3-, 6-, and 9-foot (0.9, 1.8, and 2.7 meters) intervals on dredged materials at Port St. Joe, Florida. The shoalgrass planted at 3-foot intervals joined together from adjacent plugs within 9 months. Growth at 6-foot intervals was also good.

The number of plant units (sprigs, plugs, or E-Z fabric squares) required for a given project is based on spacing requirements. For example, 18- and 36-inch (46 and 91 centimeters) spacing requires 19,400 and 4,840 units per acre, respectively.

VII. ESTIMATING LABOR AND MATERIAL COSTS

Estimated costs of transplanting seagrass, from four sources, are given in Table 2. Although costs on planting the Gulf of Mexico seagrasses by plugs are not available, it is assumed that the costs would be similar to those for eelgrass (Table 2). The same holds true for transplanting by sprigs or sprigs woven into E-Z fabric mesh. Caution should be taken in using these estimates. The costs relate to the year the research was done, the hourly wages of the workers, and the experience of the workers. The costs have been developed by small-scale field intensive research rather than by large-scale projects. Therefore, the cost of transplanting can be extremely variable.

VIII. FERTILIZATION AND HORMONE TREATMENT

The use of fertilizer is discouraged in transplanting seagrasses. No improvement in transplant success or growth from adding fertilizer was observed by Churchill, Cok, and Riner (1978) and Phillips (1976) for eelgrass and Eleuterius (1974) for turtle grass, shoalgrass, and manatee grass.

Thorhaug (1974) reported substantial root growth in turtle grass seedlings, which led to more successful establishment, when the seedlings were dipped for 1 hour in naphthalene acetic acid (NAPH). However, Churchill, Cok, and Riner (1978), van Breedveld (1975), Eleuterius (1974), and Phillips (unpublished research, 1974-1979) found that NAPH did not aid in the growth of vegetative plants. Eleuterius stated that the hormone treatment may have killed some plants.

IX. SELECTED ENVIRONMENTAL CONDITIONS

1. Depth.

The depth distribution of seagrasses depends on a complex of interrelated factors: waves, currents, substrate, turbidity, and light penetration. In the temperate zone eelgrass occurs from low tide to about 33 feet (10 meters) deep (Phillips, 1974). Cottam and Munro (1954) observed eelgrass down to 100 feet (30 meters) where the water was clear. In the tropics shoalgrass grows in the intertidal to 45 feet (14 meters) deep (personal observations at St. Croix, Virgin Islands), while turtle grass and manatee grass grow from the low tide line to 35 and 55 feet (11 and 17 meters) deep, respectively (personal observations). Phillips (1960) observed turtle grass down to 100 feet in extremely clear water in the Bahamas. In very turbid waters seagrasses are restricted to less than a 3-foot depth (Thayer, Wolfe, and Williams, 1975).

2. Light.

Backman and Barilotti (1976) demonstrated that eelgrass flowering and density in a southern California lagoon were inversely related to light intensity and penetration through the water column. Using canopies over growths in shallow water, they reduced down-welling illuminance by 63 percent, simulating light conditions extant at the lower limit of eelgrass growth. After 18 days, mean shoot densities under the canopies decreased relative to that of adjacent unshaded growth. After 9 months, shoot densities declined to 5 percent of the adjacent control unshaded growth. Flowering was also reduced under the shading canopies. Some shading could occur with increased water turbidity caused by an increased silt load from sewage effluents, nearby dredging, or even oilspills. Long-term shading could reduce seagrass density, increase erosion of bottom sediments, and affect seagrasses in adjoining areas.

3. Temperature.

All seagrass species appear to have upper and lower temperature tolerance levels (McMillan, 1978; Thayer, Wolfe, and Williams, 1975). These levels vary with the local area (McMillan, 1979; Phillips, unpublished research, 1974-1979). Eelgrass at the northern and southern extremes of distribution on both the Atlantic and Pacific coasts appears to tolerate a much broader temperature range than that in the middle of the range.

In Alaska, Biebl and McRoy (1971) found that tidepool eelgrass showed increased photosynthesis up to 95° Fahrenheit (35° Celsius) while photosynthesis in subtidal plants declined above 86° Fahrenheit (30° Celsius). The tidepool plants were also more cold-resistant.

Zieman (1975b) reported that photosynthesis in turtle grass sharply declined both above and below 82° and 86° Fahrenheit (28° to 30° Celsius). Thorhaug and Stearns (1972) reported that turtle grass growing at artificially elevated temperatures produced flowers but no fruits. McMillan (1979) found that turtle grass from a wide latitudinal gradient formed an adaptive tolerance to chilling, the broadest tolerance range in the northern Gulf of Mexico and the narrowest in St. Croix.

Wood and Zieman (1969) reported that blades of turtle grass formed large necrotic and discolored areas when stressed by high temperature. Persistent thermal stress resulted in the loss of leaves and eventually raised sediment temperatures by heat conduction. Higher sediment temperatures increased the respiration of rhizomes and caused the complete collapse of stressed populations.

4. Salinity.

Salinity changes do not appear to be as critical as temperature changes, although seagrasses do have a tolerance range to salinity. The range for eelgrass appears to be 10 to 30 parts per thousand (Phillips, 1972). Phillips (1960) reported a range of 20 to 35 parts per thousand for turtle grass. The range of manatee grass is narrower, 20 to 35 parts per thousand (McMahan, 1968). Shoalgrass in the tropics has the widest tolerance range (3.5 to 60 parts per thousand). McMillan and Moseley (1967) found that shoalgrass has the greatest resistance to high salinity, turtle grass intermediate, and manatee grass the least resistant.

A more restricted range of salinity is recommended for areas designated for transplanting seagrasses than these seagrasses will actually tolerate (cf., Figs. 1, 2, and 3). This restricted salinity range should aid in a faster establishment on a soil type which is possibly different from the source and could ameliorate possible plant-substrate nutrient interactions.

5. Nutrients.

Nutrients in the water column are not a limiting factor for seagrasses. The major nutrient activity is in the sediment. The reducing environment created in the substrate forms a sink for many heavy metals (Parker, 1962; Parker, Gibbs, and Lawler, 1963; Zieman, 1975a). There is no evidence that these metals affect the seagrasses.

Seagrass meadows are extremely important in the cycling of nutrients. Nitrogen, carbon, sulfur, and other nutrients are converted into more usable forms for other organisms. These nutrients are absorbed by the plants through the roots and pumped into the water mass.

Patriquin and Knowles (1972) found nitrogen fixed in the rhizosphere of eelgrass. McRoy and Barsdate (1970) reported that eelgrass leaves absorb phosphorus, but the major pathway is from the roots to the leaves and into the water column.

Seagrasses appear to maintain an active sulfur cycle (Wood, Odum, and Zieman, 1969). An accumulation of detritus leading to anaerobiosis below the sediment surface and an abundance of sulfur bacteria lead to this cycle. The thin, oxidized sediment surface layer promotes sulfate accumulation, but sulfides are produced in the lower layers. Fenchel (1973) found the decomposition of material in the underlying anaerobic sediments slow but favoring the release of mineral nitrogen, phosphorous, and readily assimilable organic constituents.

Seagrass detritus is extremely important in nutrient cycling within and across ecosystem boundaries. Detritus from decaying leaves is deposited in sediments in seagrass meadows, but may be flushed out of the system. Fenchel (1977) reported that microbial decomposition of seagrass detritus is of prime importance in nutrient release and cycling. Many nutrients are released as plant exudates during plant growth. Bacteria form a film around detritus particles, enriching the particles with nitrogen and phosphous which, in turn, provides enriched nutrients for animal ingestion.

6. Currents and Waves.

Churchill, Cok, and Riner (1978) reported that tidal currents as low as 0.82 knot (1.5 kilometers per hour) completely washed out transplants of eelgrass sprigs within 3 months in dredged materials in Great South Bay, New York. Plugs of eelgrass were washed away within 2 weeks in currents of 1.3 knots (2.4 kilometers per hour) in Great South Bay. In Puget Sound, Washington, some of the most vigorous eelgrass flourished where tidal currents approached 3.5 knots.

Shoalgrass plugs were presumably washed away by 2 weeks of heavy surf with waves 4 to 6 feet (1.2 to 1.8 meters) high at Port St. Joe, Florida (Phillips, Vincent, and Huffman, 1978). This occurred after a year of excellent growth of the plants on dredged materials. Thorhaug (1976) reported that heavy wave action and periodic boat wakes adversely affect the establishment and growth of turtle grass seedlings.

Eleuterius (1974) found that planting sites with bottom slopes of more than 12° and heavy wave and current action did not favor the establishment of turtle grass, shoalgrass, and manatee grass. He added that submerged transplanting operations were hindered by wind velocities above 8 knots (15 kilometers per hour) and that low tides favored submerged transplanting. In the Mississippi Sound, anchors were required for seagrass sprigs. Waves and currents washed all unanchored sprigs from control and dredged material sites. All transplants in dredged materials failed because of instability of the bottom. Erosion in the area was severe because of very strong tidal currents. In one 6-month period, 24 inches (61 centimeters) of sand was deposited over the transplants. Eleuterius (1974) reported that sediment deposition rates greater than 1 inch (2.5 centimeters) per month exceeded the growth rates of turtle grass and manatee grass, and a deposition rate greater than 2 inches (5 centimeters) per month exceeded the growth rate of shoalgrass. He theorized that initial transplants could not adjust to rapid increases in substrate elevation. He found that few transplants were killed by moderate erosion rates of 2 inches per month or less.

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